XI. "On the Influence of Temperature on the Electric Conducting-Power of Alloys." By A. Matthiessen, F.R.S., and C. Vogt, Ph.D. Received June 11, 1863.

(Abstract.)

The subject of this paper has been divided into four parts, viz.:—

I. Experiments on the influence of temperature on the electric conducting-power of alloys composed of two metals.

II. Experiments on the influence of temperature on the electric conducting-power of some alloys composed of three metals.

III. On a method by which the conducting-power of a pure metal may be deduced from that of the impure one.

IV. Miscellaneous and general remarks.

In the first part, after having given the numerical results, we proceed to explain the law which regulates this property. It is as follows:—

The observed percentage decrement in the conducting-power of an alloy between 0° *and* 100° *C. is to that calculated between* 0° *and* 100° *C. as the observed conducting-power at* 100° *C. is to that calculated at* 100° *C.*

Or in symbols,

$$Po : Pc :: \lambda_{100^\circ} : \lambda'_{100^\circ},$$

where Po and Pc represent the observed and calculated percentage decrements in the conducting-power of the alloy between 0° and 100° C.; and λ_{100° and λ'_{100° its observed and calculated conducting-power at 100° C., Pc is equal in nearly all cases to 29·307 *, the exceptions being only in the instances of thallium and iron alloys†.

The above law holds good for most of the alloys belonging to the first and third groups, as well as for a part of those belonging to the second group ‡.

Now, if the above proportion,

$$Po : Pc :: \lambda_{100^\circ} : \lambda'_{100^\circ}, \quad \ldots \ldots \quad (1)$$

be converted into terms of resistance, the following formula is obtained,

$$r_{100^\circ} - r_{0^\circ} = r'_{100^\circ} - r'_{0^\circ}, \quad \ldots \ldots \quad (2)$$

where r_{100°, r_{0°, r'_{100°, and r'_{0° represent the observed and calculated

* Phil. Trans. 1862. † Proc. R. S. xii. 472. ‡ Phil. Trans. 1860, p. 161.

resistances at 0° and 100° C. The formula, however, expresses the fact *that the absolute difference between* 0° *and* 100° *C. in the resistance of an alloy is equal to the absolute difference between* 0° *and* 100° *in the calculated resistance of the alloy.*

Formula 2 may also be written

$$r_{100°}-r'_{100°}=r_{0°}-r'_{0°},$$

which, if correct, leads to the expression

$$r_t-r'_t=r_{0°}-r'_{0°};$$

that is, *the absolute difference between the observed and calculated resistances of an alloy at any temperature equals the absolute difference between the observed and calculated resistances at* 0° *C.*; *or, in other words,*

$$r_t-r'_t=\text{a constant.} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (3)$$

After giving various examples to show the correctness of the above, we prove that from the expression

$$r_t-r'_t=\text{a constant} \qquad (3)$$

we may deduce the formula for the correction of resistance or conducting-power for temperature of an alloy as soon as we know its composition and its resistance at any temperature; for, as $r'_{100°}$, $r'_{0°}$, and r'_t may be calculated with the help of the formula given for the correction of conducting-power for temperature for most of the pure metals, if the constant $rt-r't$ be determined, then

$$\begin{aligned} r_{100°} &= r'_{100°}+\text{constant}, \\ r_t &= r'_t+\text{constant}, \\ r_{0°} &= r'_{0°}+\text{constant}; \end{aligned}$$

and from these terms the formula for the correction of resistance or conducting-power for temperature may be calculated, which in most cases will be found very near the truth.

In the second part we show by a few experiments that most alloys of three metals will probably be governed by the same law with respect to the influence of temperature on their conducting-power as alloys of two metals.

In the third part we deduce

$$\text{P} : \text{P}' :: \text{M}_{100°} : \text{M}'_{100°} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (4)$$

(where P and P′ represent the observed and calculated percentage

decrements in the conducting-power of impure and pure metals between 0° and 100° C., $M_{100°}$ and $M'_{100°}$ their conducting-powers at 100° C.; P′ is for most metals 29·307) from

$$Po : Pc :: \lambda_{100°} : \lambda'_{100°}. \quad . \quad . \quad . \quad . \quad . \quad . \qquad (1)$$

For when we consider the last two terms of the proportion, and bear in mind that a trace of another metal has very little or no effect upon $\lambda'_{100°}$ (when it represents the conducting-power of an alloy consisting of one metal with only a trace of another metal), while it alters $\lambda_{100°}$ to a very marked extent, it is evident that $\lambda'_{100°}$ may be replaced by $M_{100°}$.

We verify this by comparing the conducting-power of a pure metal directly determined, with the conducting-power of the same metal deduced from a determination of the conducting-power of its alloy with small quantities of other metals. It is a curious fact, that the deduced values from experiments upon hard-drawn wires are in reality the conducting-powers of the annealed wire of the pure metal. After having thus verified the method, we have not hesitated to employ it in the determination of the conducting-power of certain metals which have not yet been experimented upon in a state of purity.

In the fourth part we point out, first, that the percentage decrement in the conducting-power of alloys between 0° and 100° is never greater than that of the pure metals composing them; secondly, that the conducting-power of alloys decreases with an increase of temperature (some bismuth alloys form an exception to this law); thirdly, that in some cases the percentage composition of an alloy may be deduced from its conducting-power, with the aid of the percentage decrement in its conducting-power; fourthly, the method which we have used for determining the class to which the metals belong in respect to the conducting-power of their alloys; and fifthly, that the results which we have obtained and described in this memoir fully bear out the views put forward in a former one on the chemical nature of alloys.